Automated & Emerging Technologies

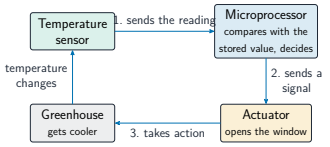
IGCSE Computer Science ▪ Topic 6

IGCSE Computer Science

What we will cover

1 Automated systems

The control loop



1. The **sensor** 传感器 measures a quantity and sends the data.
2. The **microprocessor** 微处理器 compares it with a stored value and decides.
3. It signals an **actuator** 执行器, which acts – and the loop repeats.

> Two marks nearly always sit on "compares with a stored value" and "the process repeats".

Automated systems, and the sensor for the job

An **automated system** 自动化系统 senses and responds to its **environment** 环境 with no human intervention. Central heating, a chemical process, a **greenhouse** 温室, a **car park barrier** 停车场道闸.

> Pick the sensor that reads the right physical quantity: a fish tank needs pH and temperature; an automatic door needs proximity.

Sensor	Measures	Used in
temperature	heat	ovens, greenhouses
light	brightness	automatic lights
pressure	force on a surface	alarm floor mats
infra-red / proximity	a nearby object	automatic doors
acoustic	sound level	noise monitors
humidity	water in air or soil	irrigation
gas	a gas being present	smoke alarms
pH	acidity	pools, fish tanks
accelerometer	movement or tilt	phones, airbags

Sensors, microprocessors and actuators

Three parts work together in an automated system.

> The sensor sends data to the microprocessor.

Advantages and disadvantages

Automated systems are used in many situations, such as industry, transport, agriculture 农业 (farming), weather (gathering data), gaming and lighting.

Worked example. Describe how an automatic greenhouse holds the temperature at 25 °C.

Automation: what you gain, what you give up

advantages	disadvantages
✓ work 24/7, no breaks	✗ high setup cost
✓ consistent, fewer mistakes	✗ jobs may be lost
✓ safe in dangerous places	✗ cannot handle the unexpected
✓ lower running costs over tim	✗ needs maintenance and power

- Works day and night, faster and more **consistent** 一致的 than people, and can go where people cannot.
- Costs a lot to set up, breaks down, and may replace jobs.
- It cannot react to a situation it was not built for.

2 Robotics and AI

Robotics

A robot has a **physical structure** 物理结构 (a mechanical body, such as arms), **electrical components** 电子元件 (motors, sensors, wiring), and **programmable instructions** 可编程指令 it follows and that can be changed.

A robot cannot think for itself. Ask it to handle something it was not programmed for and it stops – a **lack of independent decision-making** 缺乏独立决策.

A robot vacuum drives itself around to clean

What robots do

An industrial robot arm – reprogrammable for a new job

Robots can perform many roles, for example:

- **Factory equipment** 工厂设备: building cars, welding, moving heavy parts.
- **Domestic appliances** 家用电器: a robotic vacuum cleaner.
- They do dull or dangerous jobs quickly and accurately, and never get tired.
- They are expensive to buy and maintain, and can replace human workers.

Where automated systems are used, and what a robot is

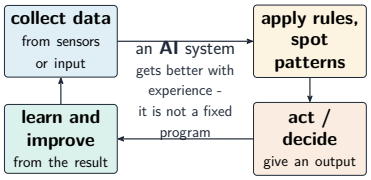
the applications	industry, transport, agriculture, weather monitoring, gas and oil, and a **greenhouse** 温室 for growing plants
the sensor types	temperature, pressure, light, moisture, pH, motion, magnetic field (door contacts, compasses), and flow or level (pipes, tanks)
the loop	sensor → microprocessor → actuator, repeating continuously
robotics 机器人技术	the branch of technology dealing with the design, building and operation of robots
what makes a robot	a mechanical structure, electrical components, and programmability
characteristics of AI	a collected data set, a set of rules for using it, the ability to reason, and the ability to learn and adapt

A robot follows a fixed program; an AI system changes its own rules from data. That difference is what the comparison question tests.

Characteristics of AI

- they **collect data** and the **rules** 规则 for using that data;
- they have the ability to **reason** 推理 (work things out using the rules);
- they have the ability to **draw conclusions** 得出结论, which may be **approximate** 近似的 (a best guess) or **definite** 确定的 (certain);
- they have the ability to **learn** 学习 from data;

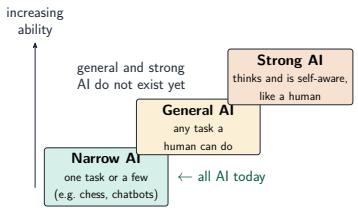
What makes a system "AI"



Artificial intelligence 人工智能 is the **simulation** 模拟 of human intelligence by a computer. Such a system:

- collects data and the **rules** 规则 for using it;
- can **reason** 推理 and **draw conclusions** 得出结论 – **approximate** 近似的 or **definite** 确定的;
- can **learn** 学习 from data and **adapt** 适应 its behaviour.

Narrow, general and strong AI



- **narrow AI** 弱人工智能 – one task or a small set (a chess program). All AI today is narrow AI.
- **general AI** 通用人工智能 – any task a human can do.
- **strong AI** 强人工智能 – would think and be self-aware.

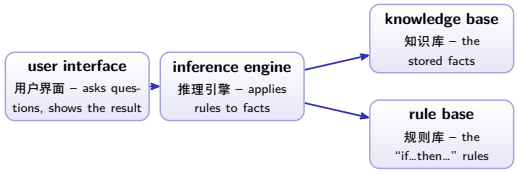
> General and strong AI do not exist yet.

Examples of AI

- **expert systems** 专家系统 – advice like a human expert, e.g. helping a doctor with a diagnosis;
- **natural language processing** 自然语言处理 – understanding speech or text;
- **self-driving cars** 自动驾驶汽车.

Sensors on the car let a computer steer it with no driver

Inside an expert system



> The interface collects facts, the engine runs the rules against the knowledge, and the system outputs a diagnosis or a probability.

Machine learning

Machine learning 机器学习 is a program that improves its own performance from experience, without being reprogrammed. It finds patterns in data and adapts.

> "Without being explicitly reprogrammed" is the phrase the mark scheme wants.

- a search engine ranks results better;
- a voice assistant recognises commands more accurately;
- a robot vacuum learns the layout of a room.

Worked example – how a greenhouse holds 25 °C

Describe how an automatic greenhouse keeps the temperature at 25 °C.

- A **temperature sensor** measures continuously and sends the reading, converted to digital by an ADC, to the **microprocessor**.
- The microprocessor **compares** the reading with the stored value of 25 °C.
- Above it, it signals an **actuator** to open a window or run a fan; below it, it switches on a heater.
- The loop then **repeats continuously**.

Two marks nearly always sit on *compares with a stored value* and *repeats continuously*. Both are easy to leave out.

Exam tips

- Learn the control loop: a **sensor** measures a quantity → the **microprocessor** compares it with a stored value → an **actuator** takes action; then the loop repeats.
- Do not confuse the parts: a **sensor** sends data *in*; an **actuator** causes movement *out*.
- A robot follows **programmable instructions** and cannot make its own decisions when something unexpected happens.
- **AI** simulates human thinking: it collects data and rules, reasons, draws conclusions, and can learn and adapt.
- Know the AI levels: **narrow** (one task; all AI today), **general** (any human task), **strong** (self-aware; does not exist yet).

3 Recap

Topic 6 – key takeaways

1 Loop
sensor → microprocessor → actuator, repeated

2 Decide
the micro compares data with stored values

3 Robot
no independent decision-making

4 AI
data + rules; learns and adapts

Check yourself

1. Which part makes the decision?
2. Which part causes movement?
3. What is a robot's key limitation?
4. What can AI do that a fixed system cannot?

Answers **1.** the microprocessor **2.** the actuator **3.** no independent decisions **4.** learn and adapt